THE TILLAGE MACHINERY LABORATORY

Division Farm Mechanical Equipment
Bureau Agricultural Chemistry and Engineering

Auburn, Alabama

The Tillage Machinery Laboratory of the Bureau of Agricultural Chemistry and Engineering, United States Department of Agriculture, was completed at Auburn, Alabama, in 1935. The purpose in establishing this laboratory was to provide facilities for comprehensive studies of tillage tools under controlled conditions in a variety of representative soils. With the facilities available, it is possible to test tillage equipment in various soil conditions within a very short period without many of the objectionable variables encountered in field testing.

General Plan of the Laboratory

The tillage machinery laboratory, Fig. 1, comprises eleven bins or plots of soil for use in making tests, an office, shop and equipment storage building, and an implement storage building. There are seven bins 20' by 250' and four bins 20' by 125', each two feet deep. The bins are separated by reinforced concrete walls fourteen inches thick, which extend ten feet beyond the ends of the bins. A 10 by 20 foot space at one end of each bin is floored with concrete for an apron on which to assemble test equipment. On the dividing walls are mounted 8 by 10 inch H-beam rails on which the testing equipment and soil conditioning equipment are operated. The only equipment to touch the soil is the tool that is being tested. The tread width for the power car, soil fitting car, and cover cars is twenty-one feet and two inches in order to straddle the plots. The walls and

Fig. 1

The Tillage Machinery Laboratory

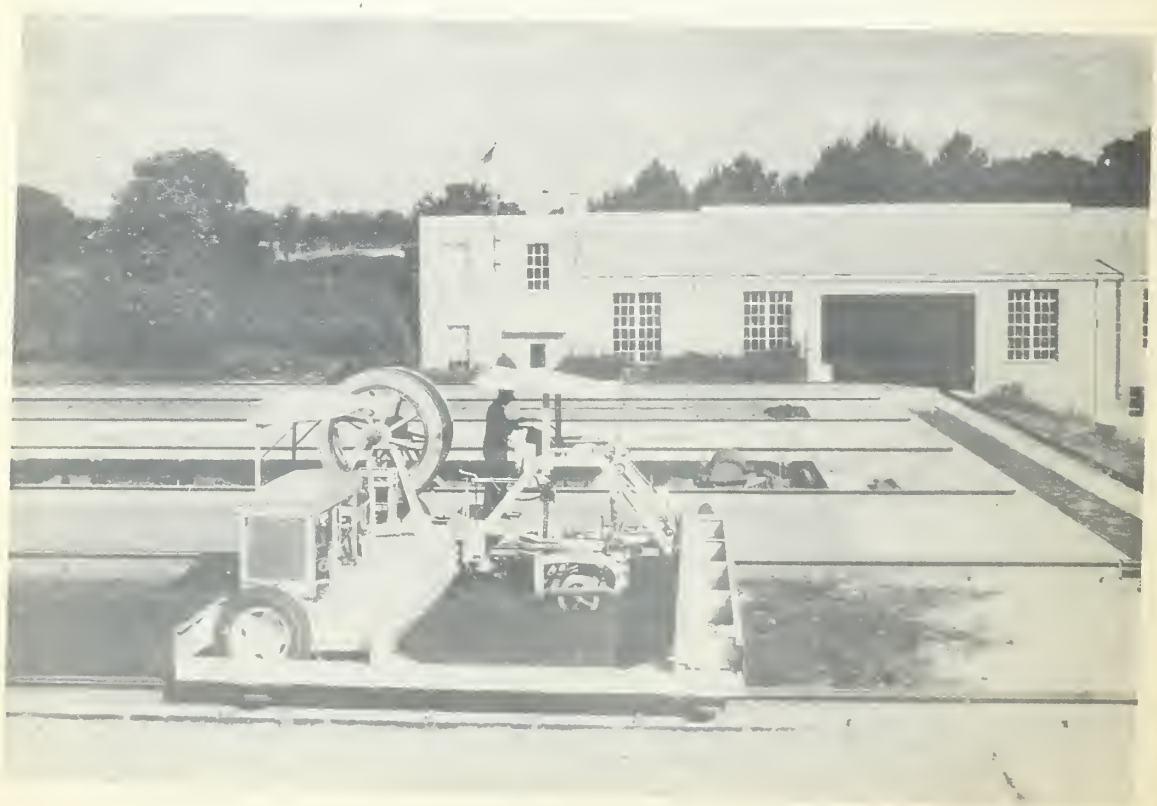

Fig. 2

Soil Fitting or Utility Car

bottoms of the soil bins are waterproofed and provided with drainage outlets.

The main building of the laboratory contains offices, soils laboratory, photographic dark room, drafting room, machine shop, and storage space for the heavy plot equipment. Facilities are available in the shop for any construction work or repair work which may be required.

The Soils

The soils in the plats or plots were selected with the objective of obtaining as broad a variation as possible in soil characteristics that affect the physical properties and tillage behavior. The selection was based on a consideration of the chief factors that cause variation in the physical properties of soils. These factors for the soils of the humid Southeastern United States are, in general, (1) the colloid content or soil texture, (2) the nature of the colloid fraction, or the chemical composition of the colloid as reflected in the silica-sesquioxide ratio (a low ratio indicating a highly weathered and mature soil with a friable clay fraction, and a high ratio indicating an immature soil with a plastic clay fraction), (3) the degree of calcium saturation or acidity, and the calcium carbonate content, (4) the organic matter content.

The soils in the plats at the laboratory with their partial analysis are as follows:

Soil Type	Sand %	Silt %	Clay %	Organic Matter %	Silica Sesquioxide ratio SiO_2/R_2O_3	pH
Norfolk Sand	89.2	2.00	8.8	.90	1.86	5.34
Davidson Loamy Sand	70.0	4.82	24.50	1.13	1.41	5.65
Davidson Clay	30.0	16.6	53.4	1.62	1.05	5.14
Cecil Clay	24.8	25.6	49.6	.48	1.23	5.08
Sharkey Clay	14.4	9.8	75.8	2.40	3.10	5.96
Lufkin Clay	20.3	12.4	67.3	2.77	3.60	5.25
Huston Clay	17.5	19.1	63.4	1.85	2.18	7.50
Oktibbeha Clay	28.5	12.2	59.3	2.03	1.83	5.10
Eutaw Clay	19.3	25.3	55.4	1.80	2.08	5.14
Decatur Clay	28.1	31.3	40.60	.98	1.83	5.64

Several of these clay soils are very difficult to handle with tillage tools and offer opportunities for experimentation in materials which might have better scouring or shedding characteristics.

To avoid as far as possible the introduction of variables into tests on the plot soils all vegetation is kept from the plots by cultivation. After four years in the bins these soils do not show any significant changes from the field soils from whence the plot soils were taken. A comparison of these analyses was made in the summer of 1939.

Soil Fitting Equipment

The equipment for fitting the soils to the desired condition for tests consists of a tractor car or utility car, Fig.2, powered by a truck motor and in which various types of tillage implements may be mounted. The tools which may be mounted in the car are a grader blade, subsoiling unit, disk unit, sub-surface packer, and smooth surface roller. A sprinkling unit is also mounted on this utility car.

The present method of fitting plot soils includes the following operations, depending upon the condition of the soil as left by the preceding test:

1. If the soil disturbed by test operations contains large lumps, they are broken by use of leveling blade or disk unit, or both as required. If no firm lumps are present, this operation may be omitted.
2. The plot is subsoiled to at least two inches below the depth of the tests to follow. This operation prevents the formation of a plow sole or line of demarcation between the soil that was worked by previous tests and

the soil below.

3. After subsoiling, the plot is leveled with the grader blade unit.
4. The plot is then rolled to the desired compactness as measured by the apparent specific gravity. Both the flat surface roller and the subsurface packer are used for this operation.
5. If necessary, water is applied with the sprinkler unit to bring it up to the desired moisture content. The water may be applied at any time during the fitting process or after the soil has been rolled, depending on conditions.
6. The final operation, usually made just before tests are run, is shaving the plot to as nearly a plane surface as possible with the grader blade.
7. The cover cars may be placed over any plot whenever it is necessary to protect the plot from weather conditions. They serve equally well for preventing the soil from drying excessively or being wet by rain.
8. Soil samples are taken to determine the moisture content and apparent specific gravity to determine the condition of the soil after the fitting operations and before each test.

Test Equipment

The test equipment consists essentially of two major units, the power car with special dynamometer and the test unit car. The power car unit furnishes the motive power and measures and records the components of draft. The test unit measures and records the forces necessary to hold the tool being tested in its working position.

The power car, Fig. 3, is equipped with a 135 H.P. gasoline engine, is mounted on eight 34" by 7" pneumatic tires and weighs approximately nine tons. The car has a speed variation from 0.2 to 10 mph (miles per hour) and will attain a speed of 6 mph in three seconds with a draw-bar load of 5,000 pounds. The hydraulic type dynamometer is of 5,000 pounds capacity, measures the three directional components of draft, and is mounted on a superframe of the power car in such a manner that it can be moved crosswise on the power car. The dynamometer can also be moved vertically for forty inches, thus enabling the hitch point to be made at about any desired position relative to the tool being tested. The three components of draft are recorded on a chart with distance and time, thus making it possible to check the components of draft and speed for any part of any test.

The test units for moldboard plows and for disks are mounted in a car which is hitched rigidly to the power car, Fig. 3. Each unit consists of a beam with the front end carried on the dynamometer and the rear end mounted on two hydraulic units supported on a frame which may be moved crosswise of the plot in the framework of the car. A third hydraulic unit is located to take the horizontal force exerted on the plow bottom or the disk by the resistance of the soil to turning. The net horizontal reaction is the algebraic sum of this force and the horizontal force on the dynamometer. The algebraic sum of the loads on the two hydraulic units supporting the beam and the vertical component on the dynamometer, minus the weight of the plow or the disk on these units, gives the upward or downward force exerted by the plow bottom or the disk. This unit with the power car dynamometer enables measuring the reactions on the tool being tested as the tool is held in its working position entirely by

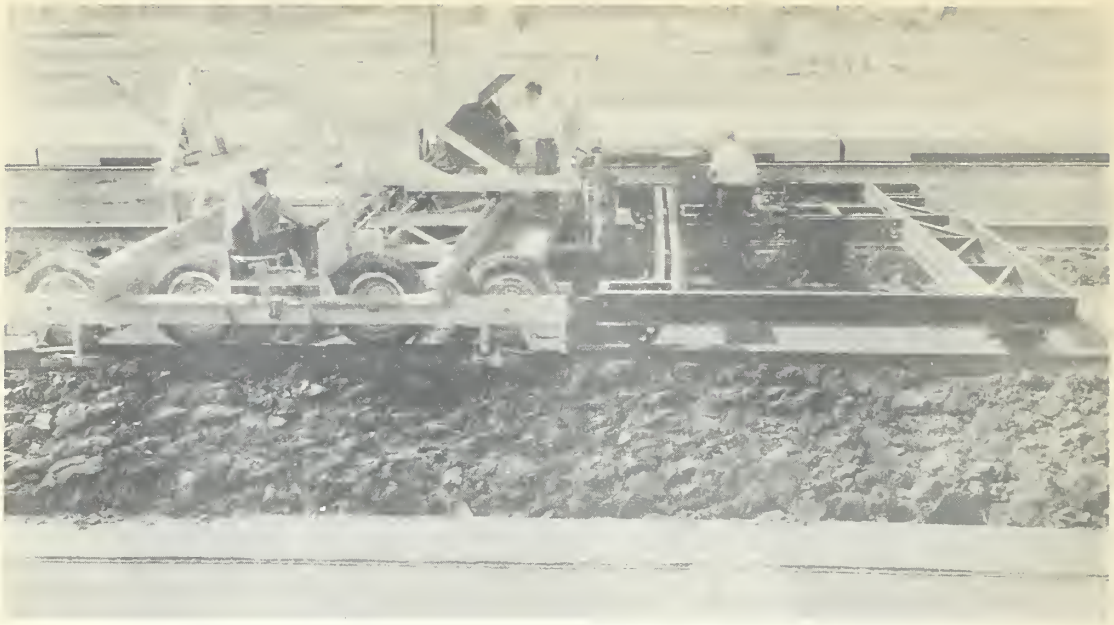

Fig. 3

Power Car or Dynamometer Car With Plow Test Unit

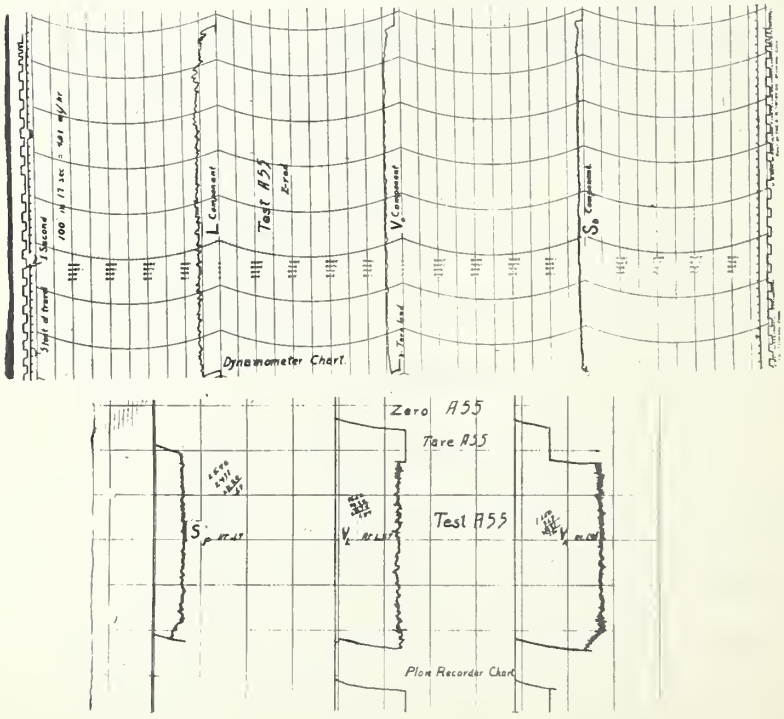

Fig. 4

Charts From Dynamometer and Test Unit Recorders

hydraulic units. The load on each unit is recorded continuously for a test. A sample chart is shown in Fig. 4.

Photographic equipment is available to aid in recording any features of any test. An addition to equipment for obtaining still photographs, two 16 mm motion picture cameras may be used for recording the action of any tool as it is tested. One of these motion picture cameras is a high speed (128 frames per second) machine which gives a slow motion picture when projected.

How to Make Use of the Tillage Machinery Laboratory

Since the facilities of the laboratory make it possible to carry on tests in various soils and under various conditions of soil in a short period of time, it is thought that tillage tool designers might desire to use these facilities. The limited equipment, of course, necessitates the carrying on of only one test or group of tests at any one time but by making arrangements previous to any desired tests, it is doubtful if any serious conflicts will occur. Anyone wishing to use the facilities of the Tillage Machinery Laboratory should write to the Division of Farm Mechanical Equipment, Bureau of Agricultural Chemistry and Engineering, Washington, D. C., giving the following information; (1) implement or tool to be tested, (2) estimated length of time necessary, (3) type of data or information to be obtained.

The personnel of the laboratory is available for operating the test equipment and also will give assistance in preparing tools for tests. The machine shop is available for any alterations in equipment or repair work which may be necessary.

In order to get the greatest return from the investment in the Tillage Machinery Laboratory, manufacturers of tillage tools are invited to make use of the facilities available in any way which may be of value. All data resulting from such tests are treated as confidential and nothing is published without the approval of the interested or cooperating agencies. Any work of this nature would be subject to the arrangement of a mutually satisfactory time, and with the understanding that all additional expense (labor, supplies, etc.) incurred because of this work be carried by the cooperating agency. And further the Bureau is to be provided with a copy of all data and reports resulting from the investigations, and the name of the Bureau or Department is not to be used in connection with any advertisements which may be based on the tests, without prior official approval, which ordinarily is not given.